

# Characteristics of Pediatric Patients Following the Kahramanmaraş Earthquake: Experience of a Major Referral Pediatric Intensive Care Unit Outside the Disaster Zone

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## ABSTRACT

**Introduction:** Earthquakes are unpredictable catastrophes that lead to an increase in critical care requirements, particularly for children. Concurrently, these often calamities decimate indispensable healthcare infrastructure, as exemplified by the Kahramanmaraş earthquake. This study aimed to examine the clinical features and outcomes of pediatric patients admitted to a remote pediatric intensive care unit (PICU) after a post-earthquake. This study further attempts to highlight the challenges in post-disaster healthcare provision.

**Methods:** The research involved a retrospective examination of pediatric patients transferred to the PICU of University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital following the Kahramanmaraş earthquake on February 6, 2023.

**Results:** This study analyzed 35 pediatric patients admitted to the PICU, with an average age of 12 years. The median Glasgow Coma Score upon admission was 14, and the median Pediatric Trauma Score was 6. Injuries included head, spine, pelvis, and limb fractures, as well as lung injuries, renal bleeding, and splenic bleeding. The median creatine kinase level was 6591 U/L, and the median hemoglobin and serum creatinine levels were 11.8 g/dL and 0.45 mg/dL, respectively. All patients were successfully discharged from the PICU (median stay: 13 days). Twelve patients received hyperbaric oxygen therapy (HOT), with a median of 23 sessions. Only one patient required amputation, highlighting the potential of HOT for preventing limb loss.

**Conclusion:** Earthquakes pose significant challenges and necessitate rapid and effective critical care responses, particularly for children. The current study highlights the importance of a multidisciplinary approach in managing pediatric critical care needs during and after a disaster. This underscores the efficacy of HOT in preventing limb loss and the significance of antimicrobial treatment and postdisaster infection control measures. Furthermore, this study addresses the complexities of patient transfers and the identification of accompanying family members during disasters.

**Keywords:** Earthquake aftermath, emergency pediatric management, pediatric intensive care unit, post-earthquake healthcare, trauma

## Introduction

Türkiye is considered one of the most seismically active regions in the world (1). The most recent earthquakes occurred on February 6, 2023, with their epicenter in Kahramanmaraş, measuring 7.7 and 7.6 in magnitude, respectively, resulting in significant destruction and losses nationwide (2). This natural disaster severely affected infrastructure and healthcare services, with notable consequences for hospitals and healthcare workers in the region (3).

Natural disasters are unpredictable events that cause widespread damage (4). In such cases, urgent and critical care services are needed for many individuals, necessitating the prioritization and management of healthcare services. Children are also significantly affected by natural disasters and require immediate and effective critical care services (5-9).

This study aimed to examine the unusual conditions following the Kahramanmaraş earthquake, treatment processes, and transfer of pediatric patients. Additionally, we intend to elucidate the processes



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experienced in pediatric intensive care services in response to this unexpected situation in detail.

## Methods

This retrospective study was conducted at the third pediatric intensive care unit (PICU) of University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital. The 16-bed unit is located at a significant geographical distance from the earthquake zone and is one of the centers where numerous patients were transferred nationwide after the earthquake. The unit accepts approximately 500 patients each year and serves as a comprehensive referral center.

The demographic and clinical characteristics of the patients were obtained from the patient and electronic medical records. The vaccination status of the patients was assessed based on existing vaccination records.

### Inclusion Criteria

- Transferred for advanced treatment from the earthquake-affected region.
- Requiring treatment in the PICU.

### Exclusion Criteria

- Having intensive care needs unrelated to the trauma caused by the earthquake, despite coming from an earthquake-affected area (e.g., pneumonia, bronchiolitis).
- Transferring children to other units within the hospital.

### Ethical Declaration

This study was conducted with the approval of the University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital Ethics Committee (approval number: 226, date: 24.05.2023). All procedures performed in this study conformed to the ethical standards of the institutional and national research committee and with the 1975 Helsinki Declaration and its subsequent amendments.

### Statistical Analysis

Statistical analyses for this study were conducted using SPSS version 20 (IBM Corp., Armonk, NY). The normal distribution of data was assessed using the Kolmogorov-Smirnov test. Participants' characteristics, including age, Glasgow Coma Scale (GCS) scores, vital signs, laboratory values, duration of mechanical ventilator use, continuous veno-venous hemodiafiltration (CVVHDF) duration, and hyperbaric oxygen therapy (HOT) sessions, are presented as median (range). In contrast, the laboratory values are presented as median (interquartile range). The relationships between serum creatine kinase, hemoglobin, and albumin levels and the number of days in the intensive care unit (ICU) after admission were determined using the Pearson correlation test. Results were considered statistically significant when the p-value was less than 0.05.

## Results

The mean age of the 35 children admitted to the ICU was 12, with a distribution of 15 men and 20 women. The average time to admission

to the ICU after the earthquake was four days. The median GCS score of these patients was 14, and the median Pediatric Trauma Score (PTS) was 6. In the classification according to trauma sites, three patients had head injuries, one of whom had a skull base fracture. Two patients had spinal fractures, and two others had sacrum and pelvis fractures. Nine patients had upper extremity trauma, including two with fractures and seven with crush injuries. Among the 24 patients with lower extremity trauma, four had fractures, and five (one bilateral) had undergone amputations. Initially, fasciotomy was performed on seven of these patients. Two patients had spinal fractures at the L1 and L1-T12 levels, two had sacral fractures, and two had pelvic fractures. Two patients had pneumothorax, three had lung contusions, and one had alveolar hemorrhage. Additionally, one patient experienced bilateral kidney and splenic bleeding (Table 1).

Based on laboratory values upon admission to the ICU, the median creatine kinase level was 6591 U/L. The highest value measured was >202,000. The median hemoglobin level was 11.8 g/dL, and the serum creatinine level was 0.45 mg/dL (Table 2).

All patients were discharged from the PICU and subsequently from the hospital. The median length of stay in the ICU was 13 days. Five patients were intubated and all were successfully extubated. Additionally, three patients required CVVHDF (creatinine values of the patients; 3.36, 3.37, and 0.59 mg/dL. In the case of the third patient, CVVHDF was initiated at the hospital in an earthquake-affected area where the initial intervention occurred. A total of 27 patients (77.1%) patients underwent surgical interventions during the intensive care course. The most commonly performed procedure was debridement (23 patients; 65.7%). Twelve patients received HOT. The median number of treatment sessions administered was 23, with the number of sessions ranging from 20 to 53. Only one patient required amputation as a result of treatment, involving the distal joint of the fourth finger (Table 3).

When examining the relationship between the admission day to the ICU and laboratory tests, a negative correlation was observed for hemoglobin levels ( $\rho$ : -0.54,  $p < 0.05$ ), serum albumin ( $\rho$ : -0.5,  $p < 0.05$ ), and creatine kinase ( $\rho$ : -0.59,  $p < 0.05$ ).

Microbiological culture samples taken upon arrival at the patients revealed microbial growth in 10 patients, nine of whom presented 4

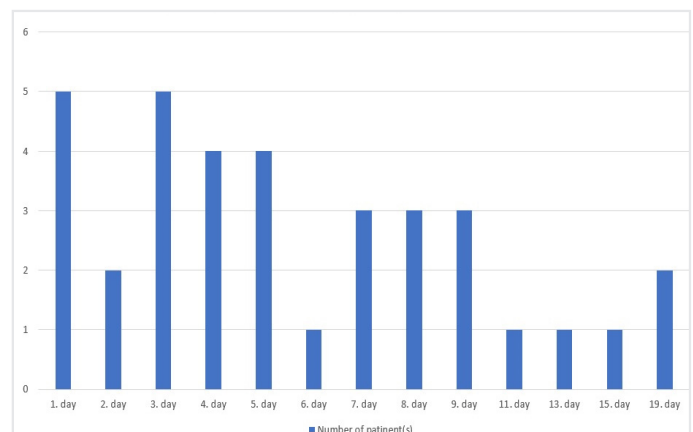


Figure 1. Number and admission days of patients following the earthquake

days after the earthquake. Microorganism growth was identified in blood, urine, and wound-site and tissue cultures. In wound cultures, antibiotic-resistant strains of *Acinetobacter baumannii* and *Klebsiella pneumoniae* were detected (other growing organisms included: blood; *Staphylococcus epidermidis*, *Staphylococcus hominis*, *Staphylococcus haemolyticus*, *Staphylococcus aureus*, *Bacillus cereus*, *Bacillus circulans*, tissue culture; *Escherichia coli*, *Citrobacter koseri*, *Pseudomonas aeruginosa*, urine; *Candida albicans*).

### Post-Earthquake Process in the Pediatric Intensive Care Unit

Following a devastating natural disaster like an earthquake, the healthcare system was forced to accommodate an increasing number of injured patients, particularly vulnerable groups such as children. The hospital's 16-bed PICU had to rapidly expand its capacity to treat more critically ill children.

Initially, the hospital administration decided to increase the PICU capacity from 16 to 32 beds and later to 48 beds. Based on this decision, a unit that initially operated as intermediate-level pediatric intensive care was transformed into a third-level PICU. Intensive care nurses from the cardiovascular surgery ICU were also included in the process.

**Table 1. Demographic and clinical characteristics of patients admitted to intensive care unit following earthquake**

Earthquake victims	35
Age*	12 (0-17)
<b>Gender</b>	
Male	15 (42.8%)
Female	20 (57.2%)
GCS*	14 (6-15)
PELOD-2 score*	0 (0-10)
PTS*	6 [(-8)-8]]
<b>Vital signs</b>	
Heart rate (beats per minute)	109 (154-68)
Systolic arterial pressure (mmHg)	117 (142-82)
Diastolic arterial pressure (mmHg)	70 (96-46)
Oxygen saturation level (%)	98 (100-93)
Respiratory rate (breaths per minute)	21 (28-12)
<b>Trauma site</b>	
Head	3 (8.5%)
Thorax	4 (10.4%)
Abdomen	2 (5.7%)
Upper extremity	9 (25.7%)
Lower extremity	24 (68.5%)
Spinal	2 (5.7%)
Sacrum	2 (5.7%)
Pelvis	2 (5.7%)
<b>Amputation</b>	
Upper extremity	1 (2.8%)
Lower extremity	4 (11.4%)

\*Median values (range).  
CVVHDF: Continuous veno-venous hemodiafiltration, HOT: Hyperbaric oxygen therapy, IMV: Invasive mechanical ventilation, PICU: Pediatric intensive care unit

**Table 2. Initial laboratory results of patients admitted to intensive care unit following earthquake**

<b>Whole blood count</b>	
White blood cell (cells/ $\mu$ L)	12.2 (6)
Hemoglobin (g/dL)	11.8 (2.4)
Platelet count (platelets/ $\mu$ L)	296 (153)
<b>Coagulation parameters</b>	
Interquartile range	1.1 (0.1)
APTT	29.6 (7.65)
Fibrinogen (mg/dL)	527 (191)
D-dimer (ng/mL)	3.73 (3.8)
<b>Serum biochemistry</b>	
Blood urea nitrogen (mg/dL)	21.9 (40.3)
Serum creatinine (mg/dL)	0.45 (0.28)
Serum uric acid (mg/dL)	2.65 (2.95)
Alanine aminotransferase (U/L)	119 (152)
Aspartate aminotransferase (U/L)	208 (462)
Albumin (g/dL)	32 (8.7)
Creatine kinase (U/L)	6591 (24058)
Amylase (U/L)	55 (56)
Lipase (U/L)	32 (75)
Sodium (meq/L)	137 (6)
Potassium (meq/L)	4.2 (0.9)
Calcium (meq/L)	8.5 (1.3)
Phosphorus (meq/L)	3.6 (1.2)
C-reactive protein (mg/L)	55 (134)
Procalcitonin (ng/mL)	0.4 (2.8)
<b>Blood gas analysis</b>	
pH	7.45 (0.1)
PCO <sub>2</sub> (mmHg)	39 (7.7)
Bicarbonate (mmol/L)	27 (4.2)
Base excess (mmol/L)	2.6 (3.8)
Lactate (mmol/L)	1.4 (0.8)

\*The data in the table is presented as median (interquartile range), APTT: Activated partial thromboplastin time

**Table 3. Interventions and treatment processes in PICU**

Surgical intervention [number of patient (%)]	27 (77.1%)
Fasciotomy opening/closure	7 (20%)
Fracture repair	6 (17.1%)
Amputation	5 (14.2%)
Flap surgery	4 (11.4%)
Debridement	23 (65.7%)
Patients who received HOT [number of patient (%)]	12 (34.2%)
Number of HOT therapy*	23 (20-53)
IMV (number of patient [%])	5 (14.2%)
The length of IMV (day)*	6 (1-68)
CVVHDF [number of patient (%)]	3 (8.5%)
The length of CVVHDF (hour)*	286 (154-418)
The length of stay in PICU*	13 (1-103)

\*Median values (range).  
CVVHDF: Continuous veno-venous hemodiafiltration, HOT: Hyperbaric oxygen therapy, IMV: Invasive mechanical ventilation, PICU: Pediatric intensive care unit

The interdisciplinary team (including pediatric surgery, orthopedics, plastic surgery, cardiovascular surgery, pediatric infectious diseases, pediatric nephrology, pediatric psychiatry, hyperbaric and underwater medicine, and social healthcare workers) coordinated their efforts during morning rounds held at 09.00 a.m. daily. The hospital administration coordinated with local and regional authorities and other hospitals for the transfer of non-critical patients and for the reconstruction of earthquake victims.

## Discussion

Earthquakes are natural disasters that simultaneously affect many individuals. Such events necessitate the simultaneous treatment of many critically ill children. The current study examined the clinical findings, treatment processes, and outcomes of child earthquake survivors admitted to the ICU after the earthquake.

First, all child earthquake survivors admitted to the ICU were successfully discharged from the PICU. Survival among all patients is the most critical finding of this study. After a catastrophic event like an earthquake, these children were able to continue their lives by being transferred to a hospital away from the earthquake-affected area. This emphasizes the importance of critical patient care.

Another critical finding was the efficacy of HOT. HOT is a preferred adjunctive treatment for critically compromised tissue oxygenation. Crush injuries, compartment syndrome, and other acute traumatic ischemic events are among the primary conditions in which this treatment is applied (10). Prior to the earthquake, children who were perfectly healthy were at risk of limb loss due to crush injuries they suffered during the earthquake. Among the 35 patients referred to our unit, five (14%) experienced limb loss as a result of amputation. However, only one of the 12 patients who received HOT underwent amputation, resulting in the loss of the distal joint of the fourth finger. After an earthquake, not only physical health but also quality of life is of great importance. One of the reasons for the high number of patients transferred to our hospital was the availability of HOT. The results of our research emphasize the critical importance of HOT, which has the potential to prevent limb loss in crush injuries following earthquakes.

Following an earthquake, critically ill children in the earthquake-affected region were rescued from the rubble. Elevated acute creatine kinase levels associated with crush injuries are a significant complication in earthquake victims (11). Because the rescue operations continued for days, child admissions occurred at different time intervals and under changing clinical conditions. In the initial days, patients had higher creatine kinase levels, and as the admission day progressed, a decrease in these values was observed, indicating a negative correlation.

Immediately after the earthquake, patients were rapidly transferred to other cities. However, in the subsequent days, healthcare services in the earthquake-affected region were swiftly organized; initial treatments were administered there, and then transfers were made. We attribute this change in treatment to the effect of fluid therapy administered before transfer to earthquake-stricken regions. Thanks to this treatment, the patients' urine output and creatine kinase levels decreased before being admitted to our unit.

The presence of resistant pathogens in children after an earthquake is a significant issue (12). Microbiological culture results indicate a high-risk of post-earthquake infection, particularly in the presence of pathogens with high antibiotic resistance. Therefore, it emphasizes the importance of appropriate antimicrobial treatment practices and infection control measures. Tetanus, which has a high incidence of injury, poses a risk following an earthquake disaster (13). Reviewing tetanus immunoprophylaxis and vaccination programs is important for protecting patients against post-earthquake health risks. In this study, tetanus immunoglobulin was provided to patients with incomplete vaccine doses, and both tetanus immunoglobulin and tetanus vaccine were administered to patients with unidentified or migrant identities to ensure tetanus protection.

An earthquake affects not only children but also their parents and close relatives. Therefore, the transfer of child patients from different cities was an important process. Determining the relationship of those accompanying children is of great importance. Additionally, family members who had lost their identities during the earthquake were considered. Therefore, after the intensive care needs of the patients were resolved, the identification of relatives accompanying the children was carried out in collaboration with local authorities and social services agencies. The process for identifying relatives of children living in Türkiye as migrants was longer.

Patients with identified identities were transferred to the service along with their identified relatives. Patients without accompanying relatives and migrant patients with relatives in the process of identity verification were placed in the service under the supervision of social workers. Thus, the safe and orderly placement of children affected by the earthquake in the services was ensured. Throughout this process, a sensitive and effective approach to the needs of patients and their families was demonstrated.

We believe that this study can serve as a useful guide by providing essential information on the management of pediatric critical care needs following an earthquake and aiming to better understand the processes in the field of pediatric critical care in disaster situations. The findings emphasize the importance of a multidisciplinary approach in the management of pediatric critical care needs after a disaster.

In disaster situations, effective collaboration among healthcare providers, local authorities, and social service agencies is of great importance for providing critical pediatric care services. In this study, issues such as service transfer processes and the identification of patient relatives were successfully managed through the coordination of all relevant parties.

## Study Limitations

Our study has some limitations. First, this was a single-center study, and the generalizability of the findings may be limited. Conducting more comprehensive, multicenter studies on the management of pediatric critical care needs after earthquakes will contribute to the knowledge in this area. Additionally, our study does not provide information about the long-term outcomes and quality of life of patients. Future studies evaluating the long-term outcomes of pediatric critical care patients

after earthquakes and the changes in their quality of life could make significant contributions to the literature in this field.

## Conclusion

This study aimed to examine the management of pediatric critical care needs following the Kahramanmaraş earthquake, with the goal of better understanding and managing pediatric critical care processes in disaster situations. Additionally, the findings highlight the high survival rates of pediatric earthquake survivors in intensive care and underscore the potential of HOT for preventing limb loss in crush injuries.

Effective collaboration and coordination among post-disaster healthcare providers, local authorities, and social service organizations are of paramount importance. This study addresses topics such as patient transfer processes and post-intensive care support, emphasizing the critical nature of this collaboration and coordination.

The findings of this study shed light on the importance of a multidisciplinary approach in managing pediatric critical care needs following disasters. Furthermore, it serves as a valuable guide for enhancing the understanding of pediatric critical care processes during disasters.

## Ethics

**Ethics Committee Approval:** This study was conducted with the approval of the University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital Ethics Committee (approval number: 226, date: 24.05.2023).

**Informed Consent:** Retrospective study.

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## Footnotes

**Authorship Contributions:** Surgical and Medical Practices - M.Ç., M.A.K., S.Y.; Concept - M.Ç., R.G., M.Çet.; Design - M.Ç., R.G., M.Çet.; Data Collection or Processing - M.A.K., S.Y.; Analysis or Interpretation - M.A.K., S.Y., M.Çet.; Literature Search - S.Y., R.G.; Writing - M.Ç.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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